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Geo-Polymer Concrete Mixture with Partial Plastic Granules as M-Sand Replacement

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Abstract- The purpose of this study is to overcome the plastic material which is being wasted are used as fine aggregates in geo-polymer concrete mixture. Plastic granules were used as the replacement for fine aggregates. The compressive strength of different specimen was conducted to check the property of plastic granules and evaluate the effectiveness of the specimen compared to normal concrete. The alkaline liquids used in this study for the geo-polymerization are sodium hydroxide (NaoH) and sodium silicate (Na2SiO3). The test specimens were (150 x 150 x 150) mm cubes. The geopolymer concrete specimens are tested for their compressive and split tensile strength at the age of 7 and 28 days. The test results indicate that the combination of fly ash and alkaline solution can be used for development of geo-polymer concrete. This study ensures that reusing waste plastic as a sand-substitution aggregate in concrete gives a good approach to reduce the cost of materials and solve some of the solid waste problems caused by plastics.

Keywords: Geo-polymer, Alkaline activator, Fly ash, HDPE (single used plastic).

I. INTRODUCTION

The most common construction material is the concrete which requires large amount of natural resources and energy. Natural resources used in concrete mixtures include lime stone, clay, sand, natural gravel, crushed stone and water. These natural resources get depleted as the urban areas grow rapidly; these resources get depleted more in the recent years in the increasing rate.

Cement industry contributes around 2.8 billion tons of the greenhouse gas emissions annually, or about 7% of the total man-made greenhouse gas emissions to the earth's atmosphere. Therefore, it is necessary to develop a new material that consumes less natural resources and energy in order to make our construction methods more sustainable. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementations binder phase or as aggregates.

Many efforts have been made in 1978, Professor **Joseph Davidovits** introduced the development of mineral binders with an amorphous structure, named geopolymers. Davidovits (1988, 1994) proposed that an alkaline liquid could be used to react with silicon (Si) and the aluminium (Al) in a source material in by-product materials such as GGBS and rice husk ash to produce binders.

The chemical reaction that takes place in this case is a polymerization process; he coined a term "Geopolymer" to represent these binders. This was a class solid material, produced by the reaction of an alumino silicate powder and an alkaline liquid. Geopolymer concrete is starting to revolutionize concrete. to study the use of waste/by product materials, such as fly ash, GGBS, silica fume, and natural pozzolana, to replace Portland cement in a concrete mixture. Others studied effects of plastic in concrete mixtures as aggregate replacement on material properties.

II. OBJECTIVES

The objectives of this study are as follows,

- To optimize the percentage of partial replacement of plastic to concrete as partial fine aggregate replacement.
- To investigate the compressive strength of the cast specimens.

III. MATERIALS

1. Flyash:

The dust collection system extracts fly ash from the combustion gases, either manually or by using electrostatic precipitators, until it is released into the atmosphere. Fly ash particles are usually spherical, finer than Portland cement and chalk, varying from less than 1 µm to no more than 150 µm in diameter.

The forms and relative concentrations of non-combustible matter in the coal decide the fly ash chemical composition. The chemical composition consists mainly of silicon (SiO_2), aluminium (Al_2O_3), iron (Fe_2O_3) and calcium (CaO) oxides, while magnesium, potassium, sodium, titanium and sulphur are also present in lower amounts.

2. Coarse Aggregate:

In present study, coarse aggregate of size 20 mm conforming to IS: 383- 1970 is use. To assess the specific gravity of aggregates, pycnometer test is performed. Sieve analysis was done to find the aggregate fineness modulus and material passed through 20 mm sieve and retained on 4.75 mm sieve is used for the work. The surface area of the coarse aggregate is less than fine aggregate.

3. Fine Aggregate:

The Manufactured Sand (MS) is a-product of the quarrying crushing and screening process is used in this experimental work. Quarry fines consist of a graded mixture of particles formed in coarse sand, medium sand and fine sand, plus clay/silt fraction known as the 'filler' grade. The industry describes filler grade material as the material having a size of less than 0.075 mm (75 microns).

4. Alkaline Activator:

Alkaline solutions play a vital role in geopolymer concrete. In this study sodium base solutions are used in order to get the best results, AL-Si minerals are more soluble in sodium based solutions and they are also much cheaper when compared to that of potassium based solutions.

Mostly, combination of sodium base solutions is preferred than using only sodium silicate or sodium hydroxide. The combination of alkaline solution is sodium hydroxide and sodium silicate. With ratio content (Na_2SiO_3/NaOH) at 2.5.To obtain a concentration of 14 molarities, molecular weight 40 is multiplied by molarities which gives 480 grams of pellets and are to be dissolved in 1 litre of water.

5. High density polyethylene granules:

The plastics used obtained from single used plastics and crushed into powder. The crushed material is optimized to 20% of replacement with M-Sand.

IV. EXPERIMENTAL INVESTIGATIONS

1. Compressive strength:

The compressive strength conducted in compression testing machine for the cast and cured specimens with the optimized value of 20% high density polyethylene granules along with M-Sand and the results are furnished in Table.1.

Table 1. Compressive strength of concrete.

S.No.	Age of concrete	Average compressive strength (N/mm^2)
1	7	15.22
2	28	38.85

2. Split Tensile Strength Test:

At the age of 7 and 28 days, the cylindrical specimens (150mm diameter x 300mm height) were tested for evaluating the split tensile strength.

The experiment is performed by putting a cylindrical sample horizontally between a compression testing machines loading surface and the load is applied until the cylinder fails along the vertical diameter.

Table 2. Split tensile strength of concrete

S.No.	Age of concrete	Average split tensile strength (N/mm^2)
1	7	1.71
2	28	4.79

With the optimized value of 20% high density polyethylene granules along with M-Sand and the tested for split tensile strength and the results are furnished in Table.2.

V. CONCLUSION

The compressive strength of geopolymer concrete at 7 days is 15.22N/mm^2. The compressive strength of geopolymer concrete at 28 days is 38.85N/mm^2.The split tensile strength of geopolymer concrete at 7 days is 1.71N/mm^2. The split tensile strength of geopolymer concrete at 28 days is 4.79N/mm^2.

The solids in the solutions must be properly dissolved for that they must be used after 24 hours of preparing. 20% replacement of fine aggregate performed well in mixing as well as strength with HDPE. The cost of plastic granule geopolymer concrete is 20% more than the conventional concrete and leads to sustainable development.

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